# CO-CITATION AND CLUSTER ANALYSES OF EXTANT LITERATURE ON SOCIAL NETWORKS

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## Abstract

Over one billion people are currently using social media such as social websites (Facebook Newsroom 2015); consequently, numerous academic scholars have developed interest in studying the use of social media and social networks. However, few studies have focused on examining the core factors of social networks. In this study, we collected studies on social-network-related topics that were published between January 1996 and December 2014, assembling a total of 2,565 articles and 81,316 citations. Co-citation analysis and cluster analysis were applied to verify seven main factors regarding social networks: (a) the measure of complex social networks; (b) community structure; (c) strong and weak ties; (d) the evolution of social networks; (e) network structure and relationship; (f) value concept and measurement strategies; and (g) social capital. Finally, the results of this study were further discussed to elucidate the core topics relevant to social networks.

**Keywords:** social network, document co-citation, multidimensional scaling analysis, cluster analysis

## Introduction

The prevalence of the Internet has facilitated convenience in daily living. Through the Internet, people can acquire information for satisfying their daily needs. In recent

years, the rapid development of various types of Internet tool has contributed to the popularity of virtual environments including blogs, chat rooms, online games, virtual communities, and social websites. Through convenient applications on the Internet, people interact with each other and engage in activities related to daily life, electronic commerce (e-commerce), and academics by using virtual platforms (Inbaria et al. 1999; Jarvenpaa et al. 1998; Piccoli and Ives 2003; Powell et al. 2004). Among the various Internet applications, social media, including social networking sites such as Facebook, Twitter, and LinkedIn have become extremely popular in the past decade. For example, Facebook, founded in 2004, is currently the most popular social networking site in the world. People use Facebook to keep in touch with their friends and family, read about current events, and express and share their feelings with others (Facebook Investor Relations 2015). Its revenue for the year 2014 reached US$12.47 billion. On average, there were 890 million daily active users and 745 million mobile daily active users in December 2014. As of December 31, 2014, there were 1.39 billion monthly active users and 1.19 billion mobile monthly active users, and approximately 82.4% of the daily active users were outside the United States and Canada (Facebook Newsroom 2015). Social network sites have penetrated people's lives and transformed the ways they communicate. A growing development on social network sites has been devoted to the design and uses of information technology in social contexts. Social network sites are used to gather, manage, distribute, and present information to users and managers. Social network sites analyses utilize the use of the digital networks and related network-based information for understanding relationships among people, teams, departments, organizations, or markets (Ngai et al. 2015; Haynes et al. 2016). Thus, social network sites provide an opportunity for practitioners and scholars to trace, visualize, analyze, explain, and simulate the structures and behaviors of human (Agarwal et al. 2008). As a result, social network sites have been recognized as an important factor which impacts knowledge sharing (Chai and Kim 2012; Mäntymäki and Riemer 2016), marketing and product co-creation (Dwivedi et al. 2015; Haynes et al. 2016; Kapoor et al. 2016; Rathore et al. 2016; Shareef et al. 2016), privacy of personal data (Külcü and Henkoğlu 2014; Haynes et al. 2016), and people's connection with others (Ngai et al. 2015).

Because of the widespread use of Facebook, Twitter, and LinkedIn, a large number of researchers have started to explore social networking sites (Basak and Calisir 2015;

Kim et al. 2011; Dwivedi et al. 2016), including Twitter (Johnson and Yang 2009; Liu et al. 2010) and Facebook (Dhaha and Igale 2013; Park et al. 2009). Moreover, many articles have examined social networking from different perspectives, including user participation (Hu and Kettinger 2008; Lankton et al. 2012), continued usage intention (Basak and Calisir 2015; Mlaiki et al. 2013), functionalities and features (Kim et al. 2012; Lu and Hsiao 2010), role in electoral compaign (Kapoor and Dwivedi 2015) gender and age (Brooks and Anene 2012; Chakraborty et al. 2013), culture (Krasnova et al. 2012), and privacy (Lo 2010; Külcü and Henkoğlu 2014; Haynes et al. 2016). The number of research articles on social media and social networks has increased substantially. However, to the best of our knowledge, no article has addressed the core intellectual structures of social networking sites. To fill this gap, social media and social networking articles were collected and analyzed to explore the core knowledge of the social media and social networking field. The data source was the Institute for Scientific Information (ISI) Web of Knowledge database, from which 2,565 articles and 81,316 citations were obtained, spanning from January 1996 to December 2014. We applied citation and co-citation analyses to determine high-value articles and the underlying intellectual structures of social media and social networking literature. Citation and co-citation analyses are commonly used bibliometric methods for assessing consistent study areas among fields (Small 1973; Sugimoto et al. 2008; Shiau and Dwivedi 2013; Shiau 2015; Shiau et al. 2015). Moreover, cluster analysis and multidimensional scaling (MDS) analysis were performed to identify the core knowledge of the social networking. The rest of this paper is organized as follows. Section 2 covers the literature review, which included a review of the definition and framework of social networks and co-citation analysis. Section 3 describes the research methodology, explaining the method for obtaining data sources and the research process. Section 4 provides the result and discussion. Section 5 offers the conclusion, which summarizes the results of this study. Section 6 provides the implication for researchers and practitioners. Section 7 presents the study limitations and areas for further study.

## Literature review

### Social network and social networking sites

Social networks have many prospective users. For example, a social network is the integration of social relationships. Hagel and Armstrong (1997) explained social networks as an interface among users. They analyzed social networks by observing social interactions and discovered that there are relationships and cohesive forces among people causing them to share their interests. Rheingold (1993) defined social networks as an integration of social ties. In other words, a social network pertains to how people in a society interact and form relational ties. In a social network, people can instantaneously share their videos, images, and text files and establish voice communications irrespective of their locations. By communicating through various interactive methods, people with similar interests can assemble online and share their opinions (Huberman et al. 2009). In sum, social networks are established by people who enjoy sharing activities, hobbies, interests, and communication.

Social networking sites provide various interactive communications. For example, Facebook, Twitter, and LinkedIn have user-friendly interfaces that enable people to follow the lives of friends, keep track of their families, discover useful information, and engage in commercial transactions (Goldsborough 2009; Huberman et al. 2009). With the increase in the popularity of social media and social networking sites, scholars and practitioners would like to understand the user behaviors of people using these applications. For example, Shi et al. (2010) studied factors affecting the intention to continue using Facebook through user satisfaction; the factors included disconfirmation of maintaining offline contacts, disconfirmation of meeting new people, disconfirmation of information seeking, and disconfirmation of entertainment. Kim et al. (2011) examined the factors affecting the intention to continue using social networking sites, including perceived usefulness, perceived enjoyment, interpersonal influence, media influence, confirmation, and satisfaction. Chang and Zhu (2012) investigated the antecedents of the intention to continue using social networking sites including perceived bridging social capital, perceived bonding social capital, confirmation, flow experience, age, and gender. Basak and Calisir (2015) studied factors that affect the intention to continue using Facebook. Their results revealed that the intention of 62% of the Facebook users to continue using Facebook is explained

by attitude and satisfaction. Entertainment and status seeking have indirect significant effects on the intention to continue using Facebook. However, information seeking and self-expression have insignificant effects on the intention to continue using Facebook. Moreover, Kwon et al. (2014) studied motivational factors for using social networking sites and explored user acceptance of Facebook and Twitter. Their results showed that perceived mobility, usefulness, connectedness, security, and system and service quality play an important role when deciding to use Facebook and Twitter.

**Co-citation analysis**

Small (1973) proposed cocitation analysis for exploring and organizing knowledge structures and core topics of distinctive scientific fields (Grover et al. 2006; Small 1973). This analysis is a type of bibliometric method that allows quantifying the cocitation relationship between documents (Small 1973). Previous studies have indicated that co-citation analysis involves determining the frequency with which two documents are cited by a third document. Two documents are strongly correlated when they are frequently cited together by other documents (Grover et al. 2006; Kessler 1963; Shiau et al. 2015; Small 1973). Co-citation is a measure of the semantic similarity among documents that is based on citation relationships. The more co-citations an article receives, the more likely they are to be semantically related (Kessler 1963; Shiau and Dwivedi 2013; Small 1973). Because of the characteristics of co-citation analysis, many scholars use it to explore the core concerns of a field. For example, Taylor et al. (2010) used co-citation and cluster analyses to analyze the literature related to information systems from 1986 to 2005. Their results showed that the literature on information systems can be divided into literature on development and introduction, information systems strategy and commercial results, and work groups and resource allocation. Hsiao and Yang (2011) investigated the intellectual development of the technology acceptance model by performing co-citation analysis, multidimensional scaling, factor analysis, and cluster analysis. Their results showed that the intellectual development of the technology acceptance model resulted in e-commerce systems, hedonic systems, and task-related systems. Lee and Chen (2012) investigated the intellectual structure of knowledge management. They performed co-citation analysis of 10,947 articles from 1995 to 2010 and discovered that the three intellectual factors affecting knowledge management were challenges

for knowledge management, the importance of knowledge, and the creation of new knowledge. Shiau and Dwivedi (2013) used co-citation, factor, and cluster analyses to identify core factors of e-commerce research. Their results showed that the five core factors are trust, technology acceptance and technology application, e-commerce task-related application, e-markets, and identity and evaluation.

## Research methods

This study was conducted by collecting articles from the ISI electronic database, which is a premier online research platform and is frequently used by researchers for retrieving information and data. The ISI electronic database has over 1,000 valuable journals containing high quality research articles (Hu et al. 2011; Liu 2005; Pilkington and Meredith 2009). The keywords "social network" and "social media" were used to collect data. The results of the two keywords overlapped. Moreover, searches for "social network" yielded more articles than did searches for "social media." Thus, "social network" was used as the "Topic" and the article type selected was "Article." Data collected from the ISI electronic database were used to obtain literature related to social networks and cited articles. A total of 8,951 articles and 298,527 references were identified. Books and conference proceedings were excluded to ensure that the examined articles were of high quality. In sum, 2,565 articles related to social networks and 81,316 references were obtained from January 1996 to December 2014. Documents published in highly regarded journals were targeted. The stress value of MDS analysis was applied as the criterion (Kruskal 1964; McCain 1990) to determine the scope for selecting frequently cited documents related to social networks. A cocitation matrix describing the relationship between documents was proposed. Subsequently, cluster analysis was applied to explore the core topics of social networks. Finally, the two dimensions (2D) perceptual map of MDS analysis was used to depict a document–document relationship reflecting the core knowledge of social networks.

## Results and discussion

In this study, we collected 2,565 articles related to social networks and 81,316 references from the ISI electronic database from January 1996 to December 2014. We calculated the citation frequencies of the cited documents and then sorted these

documents from the highest to the lowest citation frequencies to construct a cocitation matrix for extracting highly valuable cited documents. Moreover, the stress values obtained from the MDS analysis were used to assess the goodness of fit of the data. A low stress value (<0.2) indicates that the document data exhibit a high goodness of fit (Kruskal 1964; McCain 1990). The results showed that, when the number of cited documents was≤77 (citation frequency=37, stress value=0.18342), the acquired stress value was within the criterion range, but the resulting MDS perceptual map was not clear because the number of the cited documents was too high. Therefore, this study applied cluster analysis and MDS analysis to test the stress values. Finally, the resulting perceptual map was clear when the number of the cited documents was reduced to 67 as shown in Appendix A. Therefore, 67 frequently cited documents were used to have a 67×67 co-citation matrix in conducting subsequent analysis (stress value=0.17174).

This study clustered the cocitation matrix, in which data were standardized to a z-score, of the frequently cited documents into various groups, obtaining a total of seven clusters. Based on cluster analysis results, MDS analysis was used to visually display the relationships between the 67 frequently cited documents on a 2D space. Specifically, the conceptual distances between the documents were used to discuss the relationships between the documents. The results of MDS analysis with the integration of cluster analysis are seven groups and shown in Fig. 1.

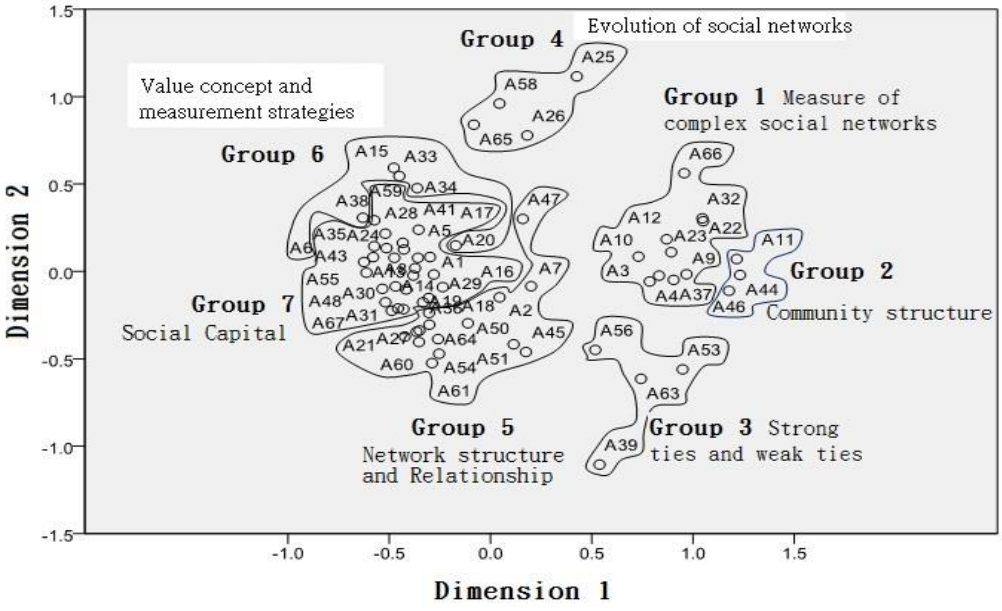


**Fig. 1** Results of the MDS analysis

Group 1 was named “measure of complex social networks” and comprised two sections: (a) the investigation of complex network structures and (b) topics associated with centrality measurement. A complex network pertains to a network structure formed through complex relational ties between numerous nodes. In terms of mathematical language, such a network can be represented by a map with complex topological features. A complex network features characteristics that are not found in simple networks such as crystal networks and random maps. Barabasi and Albert (1999) asserted that distinctive systems including genetic networks and the World Wide Web can be used to describe the complex topological structure of a network. They explained that numerous large networks commonly feature vertex connectivities following a scale-free, power-law distribution. Through empirical studies on network systems including the World Wide Web, social networks, and biological networks, scholars in recent years have developed various relevant techniques and development models for reviewing studies of associated fields (Albert and Barabasi 2002; Newman 2003). Barabasi et al. (2002) used a coauthorship method to examine the development of social networks from 1991 to 1998. Their results revealed that such networks are scale-free and that the evolution of social networks involves preferential attachment that affects both internal and external links. In addition, Barabasi et al. (2002) accentuated the importance of external links to social networks. Watts and Strogatz (1998) examined the effect of small-world connectivity on dynamical systems. They found that models of dynamical systems with small-world coupling display enhanced signal-propagation speed, computational power, and synchronizability. Jin et al. (2001) used computer simulation to emulate social network structure and proposed simple models of social networks according to three principles: (a) meetings take place between pairs of individuals at a rate that is high if a pair has one or more mutual friends and low otherwise; (b) acquaintances between pairs of individuals who rarely meet decay over time; and (c) there is an upper limit on the number of friendships an individual can maintain. Accordingly, various functions of social networks were confirmed through these models, including the high levels of cluster or network transitivity and the methods individuals use to form links with other social networks through their personal networks. Brin and Page (1998) investigated large-scale social networks and thoroughly explored major Web search engines to elucidate how to establish a practical large-scale system. Developing algorithmic tools to establish a framework for extracting information from a hyperlinked environment, Kleinberg (1999) used this framework to solve problems related to centrality, enhanced information search results, and designed the framework to analyze links by graphing them according to the connections between eigenvectors and certain matrices. Freeman (1977) proposed that each centrality measure of a social network is

based on point and graph centrality. Adomavicius and Tuzhilin (2005) addressed the field of recommender systems and adopted three methods to expand the applicability of such systems: content-based, collaborative, and hybrid recommendation approaches. In addition, they discussed a provision of more flexible and less intrusive types of recommendations. In summary, complex networks are a sociological topic warranting attention. Therefore, subsequent scholars can investigate problems related to measuring complex networks.

Group 2 was named "community structure." The documents in this cluster mainly address the concept of community or community structure in a complex network. The rapid advancement of social networks enables the prevalence of online community platforms, resulting in continual interpersonal interactions through social networks. Clauset et al. (2004) proposed a hierarchical community testing method for investigating community structure. Palla et al. (2005) defined an innovative set of characteristic quantities to uncover the overlapping community structure of complex networks in nature and society and adopted effective techniques to explore large-scale overlapping communities. Fortunato (2010) asserted that contemporary networks enhance people's daily lives. In summary, scientists have focused on examining communities in sociology, biology, and computer science to define the essential elements and problems of these fields and develop methods for displaying these elements and problems. Exploring associated document publication years revealed that scholars have just begun to explore the topic of community structure in recent years. Subsequently, this topic might be an essential research orientation for studies related to social networks.

Group 3 was named "strong ties and weak ties." The documents in this cluster primarily explain strong and weak ties in social networks. Granovetter (1973) asserted that in a conventional society, the act of contacting close relatives, classmates, friends, and colleagues is a type of stable social cognition with limited transitivity and entails the phenomenon of strong ties. In contrast with strong ties, another type of social relationship is more prevalent in conventional society; these relationships involve social cognitions with shallow relational ties and entail situations such as a person being unintentionally mentioned by other people or a person being heard suddenly on a radio broadcast. This phenomenon is called a weak tie. Brown and Reingen (1987) proposed that strong and weak ties serve dissimilar roles in a social relationship.

Granovetter (1978) explained that connecting macro and micro links is crucial in sociological theories. Milgram (1967) stated that people are likely to meet others who have left their hometowns and that, during the process of information exchange, people experience a pleasant surprise when they learn that other people share mutual friends with them; this is a type of weak tie. Goldenberg et al. (2001) conducted an experiment on people's acceptance of new products and revealed that during the process of information transmission, word of mouth is based on strong and weak ties instead of advertisements. In addition, the effect of weak ties on people's acceptance of new products is stronger than that of strong ties. In summary, research on strong ties and weak ties is applicable to various scientific fields. Exploring the collected documents revealed that numerous early scholars had already explored the topic of strong ties and weak ties. The rapid development of social networks in recent years has prompted additional scholars to investigate strong ties and weak ties in such networks (Putnam 2000). Therefore, we suggest that subsequent studies examine differences in the strong and weak ties of social networks in dissimilar enterprises and organizations.

Group 4 was named "evolution of social networks" and entailed the development and history of social networks as well as its associated definitions. Boyd and Ellison (2008) collected academic publications related to social networks from the *Journal of Computer Mediated Communication* to describe the functions of such networks and to propose a new definition of social networks from a historical perspective. In addition, they discussed essential changes in social networks, developments, and subsequent research. Davis (1989) measured computer user acceptance and satisfaction to develop and verify two variables: (a) perceived usefulness and (b) perceived ease of use. Particularly, Davis (1989) indicated that, compared with perceived ease of use, perceived usefulness was more significantly correlated with user acceptance. Venkatesh et al. (2003) conducted four research processes: (a) reviewing user acceptance literature and discussing eight prominent models; (b) empirically comparing the eight models and their extensions; (c) formulating a unified model that integrated elements across the eight models; and (d) empirically validating the unified model. Venkatesh et al. (2003) explored the following models: the theory of reasoned action, the technology acceptance model, the motivational model, the theory of planned behavior, a model combining the technology acceptance model and the

theory of planned behavior, the model of personal computer utilization, innovation diffusion theory, and social cognitive theory. Particularly, these eight models were unified into one model, namely the Unified Theory of Acceptance and Use of Technology. In summary, the number of Facebook users has rapidly increased in recent years. Ellison et al. (2007) studied the relationship between Facebook use and the formation and maintenance of social capital by assessing three types of social capital: bridging, bonding, and maintained social capital. Because the number of social network users has steadily increased along with rapid technological development, the topic of social network evaluation has become an essential research orientation for current and future studies.

Group 5 was named "network structure and relationship" and involved two types of documents: (a) the investigation of organizational structure and (b) network centrality and central position. Brass (1984) investigated personal influences in organizational structure by analyzing the relationship between structural positions and the influences of various organizational levels, namely the effect of the supervisor–nonsupervisor relationship on employee working and communication processes and friendship networks. McPherson et al. (2001) examined homophily in social networks and found that people's personal networks are homogeneous with regard to many sociodemographic, behavioral, and intrapersonal characteristics. Burt (1987) examined the social structure of personal preferences and colleagues' preferences in an organization to test social contagion and the diffusion of medical innovations. Marsden (1990) applied random and nonrandom errors to measure and examine the robustness of network structure and position. Krackhardt (1990) compared friendships and networks in a small entrepreneurial firm to assess structural cognition and organizational power. Burkhardt and Brass (1990) investigated organizational structure and power under the influence of technological changes and revealed that capable organizational employees possess adequate network cognition. Granovetter (1983) and Krackhardt (1992) respectively investigated the importance of strong ties and weak ties to internal organizational operations. Podolny and Baron (1997) examined how the structure and content of personal networks in a workplace influences intraorganizational mobility and confirmed that a person's mobility is enhanced by having a large, sparse network of informal ties for obtaining information and resources. Accordingly, Podolny and Baron (1997) developed a typology of

network contents to record employee mobility in the network structure of a high-technology firm and to analyze the interaction between the network structure and employee mobility. Freeman (1978/79) and Bonacich (1987) explored the concept and the structure of social network centrality. Ibarra (1992) analyzed the networks of men and women in an advertisement firm. Ibarra and Andrews (1993) investigated advertisement firms again to explore network centrality and proximity and elucidated differences in employee perceptions. Ibarra (1993) explored the relative effects of individual attributes, formal position, and network centrality on the execution of individual power, which was measured as involvement in technical and administrative innovations. Borgatti (2005) asserted that measuring centrality is a prevalent approach for assessing social networks. Sparrowe et al. (2001) conducted an on-site study on individual and group performances in social networks to examine the importance of centrality to social networks, enterprises, or organizations. In summary, network structure is represented by social graphs with sets of nodes (users or orgaziations) and edges (ties) linking pairs of users or organizations representing relationships among users or organizations (Brass 1984; Krackhardt 1990). Measurement of relationships can be used to assess the strangth of ties between users or organization. With network structure and relationship we could measure network centrality(Borgatti 2005). Understand network centrality is an important thing in an organization beacuse network centrality fluences not only internal organizational operations but also individual and group performance. Managers may utilize resoure in an organization.

Group 6 was named “value concept and measurement strategies” and involved (a) the value concept and organizational advantages of social capital and (b) the measurement and assessment errors of structural equation modeling, indicating that additional sociologists, political scientists, and economists have attempted to identify and expand the new concepts of social capital to their scientific fields. Adler and Kwon (2002) attempted to clarify the concept of social capital and assess organizational theories by integrating various scientific fields and formulating a mutual conceptual framework. Numerous scholars have asserted that the theory of the firm can be used to describe organizational advantages, the functions of which can effectively create and share accumulated knowledge. Nahapiet and Ghoshal (1998) proposed a model to explore a series of relationships between various dimensions of social capital and the main mechanisms and processes for creating intellectual capital.

Tsai and Ghoshal (1998) collected interview data from multiple respondents in each business unit of a large multinational electronics company to examine the structural relationship between resource exchange and product innovation in social capital and used computers as a medium to discuss the problems of electronic network implementation. Wasko and Faraj (2005) applied collective action theory to conducting network surveys and data analyses and verified that, when people contribute their knowledge, they can increase their professional reputation, acquire rich sharing experiences, and raise their statuses in a social network; these benefits prompt people to share their knowledge with strangers. Fornell and Larcker (1981) measured the shared variance in a structural model to develop and test system and measurement models. From various perspectives of social psychological research, Baron and Kenny (1986) attempted to distinguish and modify the properties of moderator and mediator. Podsakoff et al. (2003) investigated the method biases that can affect research outcomes and verified the potential sources of method biases. In addition, they examined the effect of method biases to discuss the process of cognition and assess various processes and statistical techniques. In summary, value concepts of social capital include advantage, knowledge, resource exchange, product innovation, reputation, experience, and statuse. Moreover, firms may consider social networks to be a means of gaining popularity and business benefits. Therefore, firm operators compete in social networks to enhance firm performance (Barker 2009; Lu and Hsiao 2010; Park et al. 2009; Ross et al. 2009; Zhao 2009).

Group 7 was named “social capital.” Social capital pertains to a mechanism for explaining socioeconomic phenomena and has become an accentuated research topic Burt (2000). Because social capital involves various scientific fields, such business, political science, and socialoloy, this topic has gradually become a research stream (Burt 2000; Robinson et al. 2002). For example Burt (1997) investigatged contigent value of social capital and found that the value of social capital, high on average for the managers, changed as a power function of the number of people doing the same work. Moreover, Burt (2000) did a comprehensive review on network structure of social capital and emphased at three points, including metaphor and mechanism, evidence, and complementarity in addition to conclud about specific aspects of theory and research. Granovetter (1973) analyzed the macro and micro dimensions of sociological theories, suggesting that such theories can serve as a tool for creating

relational ties. Granovetter also asserted that the extent of overlap in two people's friendship networks is directly correlated with the strength of the relational tie between them. Hansen (1999) examined complex knowledge concepts to elucidate the effects of weak ties on knowledge sharing across organization subunits in multiunit organizations. Levin et al. (2002) proposed a model based on the power of trust and weak ties to survey three companies in dissimilar countries. Uzzi (1996) developed a method for exploring how embeddedness and network structure affect economic action. Furthermore, Uzzi (1997) conducted field research on 23 entrepreneurial firms, elucidating that embeddedness is a type of exchange logic for sustaining a relationship with the market and ensuring firm survival. Rowley et al. (2000) elucidated how the properties of structural embeddedness and emotional embeddedness influence firm behavior and performance. Granovetter (1985) mainly investigated the problem of embeddedness in economic action and social structure by exploring complex economic actions. Brass et al. (2004) examined the relationship among network centrality, employees, and social relational embeddedness. Coleman (1988) introduced and illustrated the concept of social capital to examine the social structural conditions under which it arises and to analyze dropouts from high school. Burt (2004) examined the mechanism through which brokerage provides social capital and confirmed that opinion and behavior are more homogeneous within groups than between groups. Reagans and Zuckerman (2001) explored the productivity of research and development teams in 224 firms, asserting that demographic diversity can be applied to effectively redefine the network variables of various forms of social capital. Borgatti and Foster (2003) examined and analyzed the emerging models of organizational network research, reviewed recent organizational studies as well as approved research data, and applied a 2D model to construct a 2×2 network model. Barney (1991) investigated the relationship between firm resources and sustained competitive advantages and verified four potential resources for creating such advantages: value, rareness, imitability, and substitutability. Grant (1996) explored the coordination mechanisms used by firms to integrate the specialist knowledge of their employees. Reagans and McEvily (2003) investigated how network structure affects the process of knowledge transfer. Borgatti and Cross (2003) examined previous studies on social networks, information processing, and organizational learning to propose an official model for information seeking. Cohen and Levinthal

(1990) asserted that the competence of a firm in recognizing the value of new, external information and assimilating and applying such information to commercial ends is crucial to its innovative capability. Powell et al. (1996) stated that, when the basic and professional knowledge of an industry is complex and disperse, the locus of innovation is found in network learning rather than in individual firms. In addition, they developed a network approach to organizational learning. Ahuja (2000) assessed how the network relations of a firm affect innovation and elaborated a thorough theoretical framework that related a firm's direct ties, indirect ties, and structural holes. From the perspective of organizational learning networks, Tsai (2001) maintained that organizational units can produce additional innovations and exhibit enhanced performance by occupying central network positions and receiving new knowledge from other units. Obstfeld (2005) examined the behavior involved in organizational innovation and strategic positioning. In summary, concepts related to social capital have existed in the domain of sociology since their conception. Moreover, this domain incorporates fields such as sociology, political science, economics, and anthropology (Lesser 2000), showing that social capital can serve as a means for improving personal and social competence as well as a pathway for resolving contemporary social problems. Investigating the publication years of the collected documents revealed that the topic of social capital has been investigated by scholars since its conceptualization. Therefore, we suggest that this topic can be applied to not only sociology but also fields such as management information system, economics, political science, management, and anthropology.

## Conclusion

The main contributions of the present study involve proposing the core knowledge of social network research from 1996 to 2014. Social networks are a popular academic field of inquiry that has expanded rapidly. A substantial number of relevant documents have been published, discussing the topics of social capital, network structure, and complex network measures. Recent studies have also examined the evolution and use of social networks as well as strong ties and weak ties in such networks. The present study adopted cocitation, cluster, and MDS analyses to investigate the knowledge structure, core topics, and development trends of research regarding social networks. We used the ISI Web of Knowledge database to collect

2,565 source documents and 81,316 cited documents published between 1996 and 2014. Cocitation analysis was used to extract 67 frequently cited (highly valuable) documents for creating a cocitation matrix. SPSS statistical software was used to conduct relevant statistical analyses and to elaborate the core knowledge of research on social networks. The core knowledge of social network research can be categorized in seven major classes: (a) the measure of complex social networks; (b) community structure; (c) strong and weak ties; (d) the evolution of social networks; (e) network structure and relationship; (f) value concept and measurement strategies; and (g) social capital. Exploring these seven major topics revealed that social networks are mainly established through interpersonal interactions from which various operating modes emerge including strong ties, weak ties, embeddedness, and value. Current social network research mainly explores topics such as network user status, community relationships, and network centrality. Among these topics, those related to social capital account for one-third of the documents. Social capital involves organizational structure, relational ties, attitude, and value concepts and is beneficial to economic and social development. Therefore, social network researchers and operators have paid attention to topics such as interpersonal relationships, interinstitution relationships, network user attitudes, and socioeconomic enhancement. Through adequate integration and discussion, researchers can quickly and accurately identify essential topics in the field of social networks to search for applicable research topics.

The rapid development of social networks has accompanied the expeditious proliferation of various network platforms. Moreover, social network studies have measured the community relationships and centrality of such networks to expand associated scientific fields. Recently, topics related to social development and economic growth have gradually received attention. The value of social networks and the status of social network users have become essential topics explored by relevant scholars. Furthermore, fields such as medical innovation have also appeared in the field of social networks, indicating the richness, diversity, and importance of social network research to various academic fields. However, this interweaving of fields also makes it difficult to examine the definitions and core topics relevant to social networks.

## Implication for researchers and practitioners

Understanding the core knowledge of social network research enables subsequent researchers and firm operators to adequately perceive and engage in practice related to social networks. From an academic perspective, the focus of discussion regarding social networks has shifted from investigating strong ties, weak ties, and network structural ties to examining the relationships between communities as well as determining the status of social network users. Furthermore, the rapid proliferation of social networks in recent years has increased the attention on community-related discussion. On the basis of this trend, this study has organized two applicable social network research topics for future scholars: (a) The performance assessment, model, and structure of social networks can be diversified according to the scope of the involved scientific fields and the changes in social organizations. Therefore, how to enhance firm or organizational performance through social networks is a crucial research topic. (b) The usability of social networks increases with the rapid advancement of technology. The number of social network websites and users has rapidly increased. Subsequent scholars can focus on constructing frameworks and implementation models for defining the reasons that prompt people to use social network websites and for investigating why people must use such websites to satisfy their needs.

Regarding practicability, social networks have been operated for numerous years. From a contemporary perspective, network ties are an essential aspect of social interaction. By integrating the concepts of strong ties and weak ties in social networks, various social network websites, including Facebook, Line, and Twitter, have begun to emerge. Currently, practical topics of social networks have mainly emphasized integrating the ties between social networks. For example, the present study examined the factors influencing firm's word of mouth and revealed that strong ties and weak ties, instead of advertisement, are the main factors affecting word of mouth. Contemporary firms should pay additional attention to social network users and effectively utilize social networks to enhance firm performance. In addition, how to select and build relationships with members within social networks is another essential topic.

## Limitations and future study

This study had three limitations because of our research methods. First, our documents were primarily obtained through the ISI Web of Science database. The source data from the ISI electronic database did not include all research articles on social networks. We focused on data published from January 1996 to December 2014, namely that provided in 2,565 articles on social networks and 81,316 references. Future studies may collect more articles related to social networks from other databases to perform a trend analysis and explore the evolution of social network research. Second, the cocitation analysis method used in this study exhibits the problem of time delay. Therefore, numerous recent documents that are highly valuable were excluded from the study because their citation frequencies were insufficient. Future studies may consider different weights for articles published during different periods of time. New articles may have a possibility of being considered highly cited (value) articles. Finally, the composition of a scientific field's knowledge structure can change over time because of the continual publications and changes in citation frequency. In future studies, scholars could extent the period of analysis and incorporate the aforementioned problems associated with processing journal data to investigate future changes and trends in the knowledge structure of social networks, thus further perfecting the core knowledge of social networks.

## Appendix A. 67 high cited articles


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